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6. AUTHOR(S)
Alan R. Elcrat

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Wichita State University
Department of Mathematics and Statistics
Wichita, KS 67208-1595

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The research supported by this grant centered on the study of inviscid flows with concentrated regions of vorticity. There were related studies of numerical conformal mapping and construction; of minimal surfaces.

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PRINCIPAL INVESTIGATOR: Alan R. Elcrat

The research supported by this grant centered on the study of inviscid flows with concentrated regions of vorticity. There were related studies of numerical conformal mapping and construction ;of minimal surfaces.

In the paper [1] published during the completed support period the flows past a class of three dimensional bodies was studied using matched asymptotic expansions. The near field was computed using a wake theory developed earlier in [2], and the far field was obtained from a superposition of a distribution of vorticity and sources on a line segment. In another paper [3] a class of flows with constant vorticity regions were computed from a variational principle which had been used earlier in theoretical work [4] for such flows. Other published work supported by this grant was [5] in which scattering of electromagnetic waves from a dielectric slab with time varying permittivity was studied, and [6], in which the Gauss Map was used to construct a new class of minimal surfaces which become vertical on a part of the bounding curve.

During the year a comprehensive set of computations was done to compare several methods for the conformal mapping of the exterior of a disk to the exterior of bounded region. The methods tested were the classical Theodorsen method, the method of Wegmann, and the methods of Friberg and Timman. These results are potentially useful for aerodynamics for transplantation of flows and for grid generation. A paper was submitted to the SIAM Journal of Scientific and Statistical Computing and was accepted, Fall 1989. Work is in progress to extend the Timman method to domains with corners; preliminary computations are promising, and a detailed report should follow during the next period. Also, this method applies naturally to Helmholz-Kirchoff flows, and other wake models, such as that used in [1], and work is in progress to make this work computationally.

In another computational work based on a variational principle, a Prandtl-Bachelor flow, in which a constant vorticity region is bounded by a vortex sheet, was computed. The geometry was a Riabouchinsky type configuration in which an arc and its image in a reflection plane are joined by a symmetric arc which carries a vortex sheet. The procedure was based on minimizing a functional in which the main terms were Dirichlet integrals representing virtual mass and vortex energy. These were computed using conformal mapping to the unit disk and Fourier series. Work is in progress on extending these ideas to domains with cusps such as those which occur in the wake behind an obstacle. There are difficulties connected with "thinness" of such domains near the

cusps which require significant modifications to the work completed.

Finally, an extension of earlier theoretical work [4] on existence of steady vortex patches was made. In this work the class of vorticity functions used was the set of rearrangements of a fixed function. Work is in progress on developing a computational algorithm for obtaining the "profile function" which relates the vorticity to the stream function in the resulting flow.

References

[1] P. Bassanini and A. Elcrat, Separated flow past three dimensional bodies as a singular perturbation problem, J. Eng. Math. 23 (1989), 187-202.

[2] P. Bassanini and A. Elcrat, A univalent spiral-vortex model for separated flow past a polygonal obstacle, ZAMP 39 (1988) 455-467.

[3] A. Elcrat and K. Miller, Computation of vortex flows past obstacles with circulation, Physica D 37 (1989) 441-452.

[4] A. Elcrat and K. Miller, Steady vortex flows with circulation past asymmetric obstacles, Comm. in PDE 12 (1987) 1095-1115.

[5] A. Elcrat, J. Foster, and J. Walsh, Scattering of a TEM wave from a time varying slab, Microwave and Optical Technology Letters, March 1989.

[6] A. Elcrat and K. Lancaster, Bernstein Functions and the Dirichlet Problem, SIAM J. Math. Anal. 20 (1989).